

Amendments to the Specification:

Please replace the following paragraphs:

Page 5, paragraph 6:

Fig. 1 shows an apparatus for implementing an embodiment of the method of radiation measurement ~~recited in claim 1 of the invention~~ which relies upon time-division multiplexing of stimulated fluorescence and prompt fluorescence that are emitted from a stimuable phosphor;

Page 6, paragraph 2

Fig. 3 shows an apparatus for implementing another embodiment of the method of radiation measurement ~~recited in claim 2 of the invention~~ which is capable of detecting high-intensity radiation with a stimuable phosphor;

Page 6, paragraph 3

Fig. 4 shows one embodiment of the differential and integral-type apparatus for radiation measurement ~~recited in claim 3 of the invention~~ which relies upon reading the light of saturation detecting LED;

Page 6, paragraph 5

Fig. 6 shows another embodiment of the differential and integral-type apparatus for radiation measurement ~~recited in claim 4 of the invention~~ which relies upon reading stimulated fluorescence with an altered sensitivity for fluorescence detection;

Page 6, paragraph 6

Fig. 7 shows yet another embodiment of the differential and integral-type apparatus for radiation measurement ~~recited in claim 5 of the invention~~ which relies upon reading stimulated fluorescence with an altered quantity of exciting light;

Page 6, paragraph 7

Fig. 8 shows still another embodiment of the differential and integral-type apparatus for radiation measurement ~~recited in claim 6 of the invention~~ which relies upon correcting the effect of prompt fluorescence that is incident by chance during radiation measurement with stimulated fluorescence;

Page 7, paragraph 1

Fig. 9 shows an apparatus for implementing another embodiment of the method of radiation measurement ~~recited in claim 7 of the invention~~ which reads the dose of accumulated radiation in a stimuable phosphor upon illumination with pulsed-exciting light;

Page 7, paragraph 2

Fig. 10 is a timing chart for signals generated in the method of radiation measurement ~~recited in claim 7 using the embodiment of Fig. 9~~ which reads the dose of accumulated radiation in a stimuable phosphor upon illumination with pulsed exciting light;

Page 7, paragraph 3

Fig. 11 shows an apparatus for implementing another embodiment of the method of radiation measurement ~~recited in claim 8~~ which reads the dose of accumulated radiation in a stimuable phosphor using a gated photomultiplier tube as a photodetector;

Page 7, paragraph 4

Fig. 12 shows an apparatus for implementing still another embodiment of the method of radiation measurement ~~recited in claim 9 of the invention~~ which reads the dose of accumulated

radiation in a stimutable phosphor by coincident counting of photons in pulsed exciting light and stimulated fluorescence signals;

Page 7, paragraph 6

Fig. 14 shows an apparatus for implementing another embodiment of the method of radiation measurement ~~recited in claim 10 of the invention~~ which uses a stimutable phosphor to be illuminated with exciting light through laterally radiating optical fibers;

Page 8, paragraph 1

Fig. 15 shows an apparatus for implementing still another embodiment of the method of radiation measurement ~~recited in claim 11 of the invention~~ which uses a stimutable phosphor to be illuminated with exciting light through semi-laterally radiating optical fibers;

Page 8, paragraph 2

Fig. 16 shows an apparatus for implementing yet another embodiment of the method of radiation measurement ~~recited in claim 12 of the invention~~ which uses a stimutable phosphor to be illuminated with exciting light through semi-laterally radiating optical fibers in the presence of a light reflector at their back;

Page 8, paragraph 3

Fig. 17 shows a radiation detecting portion for use in an embodiment of the method of ~~claim 13 of the invention~~ which employs a stimutable phosphor in combination with a laterally radiating optical fiber and wavelength shifting optical fibers sensitive to the wavelength of fluorescence;

Page 8, paragraph 4

Fig. 18 shows a radiation detecting portion for use in another embodiment of the an
apparatus of claim 14 of the invention which is a planar array consisting, in superposition, of
laterally radiating optical fibers, a stimuable phosphor, an optical filter and wavelength shifting
optical fibers;

Page 8, paragraph 6

Fig. 20 shows a radiation detecting portion for use in another embodiment of the an
apparatus of claim 15 of the invention which is a ribbon array of laterally radiating optical fibers
sandwiched between assemblies each consisting of a stimuable phosphor, an optical filter and a
ribbon array of wavelength shifting optical fibers;

Page 8, paragraph 7

Fig. 21 shows a radiation detecting portion for use in another embodiment of the
apparatus of claim 16 of the invention which is a ribbon array of laterally radiating optical fibers
sandwiched between assemblies consisting of different stimuable phosphors, an optical filter
and a ribbon array of wavelength shifting optical fibers;

Page 9, paragraph 1

Fig. 22 shows a radiation detecting portion for use in yet another embodiment of the
apparatus of claim 17 of the invention which is a cylindrical arrangement of a laterally radiating
optical fiber, a stimuable phosphor, an optical filter and wavelength shifting optical fibers;

Page 9, paragraph 2

Fig. 23 shows still another embodiment of the apparatus for radiation measurement
recited in claim 18 of the invention which enables measurement of a positional distribution of

radiation using a multiple of series connected radiation detecting portions including a stimuable phosphor;

Page 9, paragraph 3

Fig. 24 shows another embodiment of the apparatus for radiation measurement ~~recited in claim 19 of the invention~~ which enables measurement of a positional distribution of radiation using a multiple of radiation detecting portions including a stimuable phosphor that are series connected with optical delay mechanisms;

Page 9, paragraph 4

Fig. 25 shows yet another embodiment of the apparatus for radiation measurement ~~recited in claim 20 of the invention~~ which enables measurement of a positional distribution of radiation with pulsed exciting light using a radiation detecting portion in the form of a planar array;

Page 9, paragraph 5

Fig. 26 shows still another embodiment of the apparatus for radiation measurement ~~recited in claim 21 of the invention~~ which enables measurement of a positional distribution of radiation with pulsed exciting light using a radiation detecting portion in the form of a planar array and a streak camera;

Page 10, paragraph 1

Fig. 27 shows still another embodiment of the apparatus for radiation measurement ~~recited in claim 23 of the invention~~ which enables measurement of a positional distribution of radiation with a single bundle of wavelength shifting optical fibers that read the stimulated fluorescence emitted from a multiple of stimuable phosphors provided at predetermined sites of radiation measurement;

Page 10, paragraph 2

Fig. 28 shows yet another embodiment of the apparatus for radiation measurement recited in claim 24 of the invention which produces a two-dimensional radiation image using laterally radiating optical fibers to launch exciting light;

Page 10, paragraph 3

Fig. 29 shows another embodiment of the apparatus for radiation measurement recited in claim 25 of the invention which uses the same photodetector to measure the fluorescence output from both ends of a wavelength shifting optical fiber bundle in a radiation detecting portion in the form of a planar array;

Page 10, paragraph 4

Fig. 30 shows another embodiment of the differential and integral-type apparatus for radiation measurement recited in claim 26 of the invention which uses a radiation detecting portion in the form of a planar array;

Page 10, paragraph 5

Fig. 31 shows a differential and integral-type apparatus for implementing yet another embodiment of the method of radiation measurement recited in claim 27 of the invention which applies a pulsed optically stimulated fluorescence reading technique to a radiation detecting portion in the form of a planar array;

Page 11, paragraph 1

Fig. 32 shows another embodiment of the differential and integral-type apparatus for radiation measurement recited in claim 28 of the invention which is capable of neutron measurement using both a neutron converter and a stimuable phosphor as a radiation detecting medium;

Page 11, paragraph 2

Fig. 33 shows an apparatus for implementing another embodiment of the method of radiation measurement ~~recited in claim 29 of the invention~~ which is capable of neutron measurement using a fast neutron moderator;

Page 11, paragraph 3

Fig. 34 shows another embodiment of the differential and integral-type apparatus for radiation measurement ~~recited in claim 30 of the invention~~, which is characterized by correcting the accumulated dose of radiation in a stimuable phosphor on the basis of its temperature as measured with a temperature sensor;

Page 15, paragraph 2

~~Claim 1 sets forth the basic concept of the present invention and an example of it~~
Example 1 is described below with reference to Fig. 1. As already mentioned, a stimuable phosphor which is used as a radiation detecting medium in the invention has two actions, one is accumulating an incident radiation and outputting the quantity of accumulated radiation as "stimulated fluorescence" upon stimulation by exciting light and the other is emitting "prompt fluorescence" upon excitation by an incident radiation. The basic concept of the invention is to provide a method of measuring the quantity of incident radiation by selectively detecting stimulated fluorescence and prompt fluorescence real-time at specified time intervals using a fluorescence detecting mechanism.

Page 18, paragraph 3

We now describe ~~an example of claim 2~~ with reference to Fig. 3. When stimulated fluorescence and prompt fluorescence are being detected from the imaging plate by the

fluorescence detecting mechanism at specified time intervals during radiation measurement in or around an accelerator, an intense radiation may be incident within a short time to saturate the fluorescence detecting mechanism which is no longer operational. If this occurs, no signal enters the signal processing circuit. Hence, monitoring is performed with a saturation detecting circuit which, when the fluorescence detecting mechanism is saturated, sends a saturation signal to the control circuit. When the incidence of the rapid and intense radiation has ended and the fluorescence detecting mechanism has recovered from saturation, the operation is switched to the stimulated fluorescence mode by the mode switching circuit and the stimulated fluorescence is detected, thereby measuring the rapid and intense dose of the incident radiation.

Page 19, paragraph 1

We now describe an example of ~~claim 3~~ with reference to Fig. 4. The apparatus for radiation measurement shown in Fig. 4 comprises the following components: a stimuable phosphor serving as a radiation detecting medium; an exciting light source for illuminating the stimuable phosphor with exciting light to read the accumulated dose of radiation at specified time intervals; an optical bandpass filter centered at the wavelength of fluorescence; a photodetector for detecting stimulated fluorescence and prompt fluorescence; a signal processing circuit for amplifying and processing a stimulated fluorescence signal or a prompt fluorescence signal that are output from the photodetector; a mode switching circuit for switching between the stimulated fluorescence signal and the prompt fluorescence signal at specified time intervals; a saturation detecting circuit for monitoring the operation of the fluorescence detecting mechanism; an LED for use in saturation detection; a circuit for altering the quantity of exciting light; a control circuit for controlling the exciting light source, the mode switching circuit, the saturation detecting circuit and the light quantity altering circuit at specified time intervals; a

stimulated fluorescence data collecting circuit for measuring stimulated fluorescence; a prompt fluorescence data collecting circuit for measuring prompt fluorescence; and a data processing circuit which collects stimulated and prompt fluorescence data at specified time intervals synchronously with the control circuit and determines the dose of incident radiation on the basis of the collected data.

Page 24, paragraph 1

When measuring the stimulated phosphor by this method, it is not known how much of the rapid and intense radiation has accumulated in the stimuable phosphor. To deal with this situation, the imaging plate is first illuminated with very weak exciting light and after knowing its quantity, the accumulated dose of radiation in the stimuable phosphor is read, thereby ensuring that the total dose of radiation accumulated in the stimuable phosphor is measured without causing saturation of the fluorescence detecting mechanism. Thus, according to ~~claim~~ example 3, the quantity of exciting light being applied to the stimuable phosphor is altered with the light quantity altering circuit on the basis of a signal from the control circuit while using the saturation detecting circuit as an auxiliary and this enables the dose of accumulated radiation to be read from the stimuable phosphor without saturating the fluorescence detecting mechanism.

Page 25, paragraph 1

We now describe an ~~example of claim 4~~ with reference to Fig. 6. In the previous example, the dose of an intense radiation that was incident within a short time is measured by counting the photons in stimulated fluorescence after fluorescence detecting mechanism has recovered from saturation. The same object (reading without saturation of the fluorescence detecting mechanism) can be attained by altering the sensitivity of the fluorescence detecting mechanism. In the example under consideration which uses a photomultiplier tube as the

photodetector, a bias voltage altering circuit is used to alter the sensitivity for fluorescence detection and the intended operation is performed by controlling the bias voltage with the control circuit

Page 25, paragraph 2

We now describe an example of ~~claim~~ 5 with reference to Fig. 7. This is the combination of ~~claims~~ examples 3 and 4 and is characterized in that if an extremely large quantity of radiation is incident, the sensitivity for fluorescence detection is lowered by the sensitivity altering circuit and the time taken by measurement of stimulated fluorescence is shortened. According to ~~claim~~ example 5, this and other methods may be used to optimize the reading of stimulated fluorescence.

Page 25, paragraph 3

We now describe an example of ~~claim~~ 6 with reference to Fig. 8. When the dose of incident radiation is measured at specified time intervals by counting the photons in stimulated fluorescence in the foregoing examples using a mechanism for detecting stimulated fluorescence and prompt fluorescence, the imaging plate may incidentally be illuminated with a radiation during the reading process and counted in the result of measurement. To deal with this situation, the contribution from the prompt fluorescence is corrected with the data processing circuit on the basis of the dose of radiation measured at specified time intervals by counting the photons in prompt fluorescence using the fluorescence detecting mechanism and, as a result, the total dose of incident radiation can be correctly measured.

Page 26, paragraph 1

We now describe an example of ~~claim 7~~ with reference to Fig. 9. ~~The invention recited in claim~~ Example 7 relates to a method applicable to an apparatus for radiation measurement using a stimutable phosphor and which is characterized by an improvement in the manner in which the dose of radiation accumulated in the stimutable phosphor is read.

Page 28, paragraph 1

We now describe an example of ~~claim 8~~ with reference to Fig. 11. The example is a modification of the radiation detecting apparatus recited in ~~claim example 3~~ and characterized by using a gated photomultiplier tube as the photodetector. An example of the gated photomultiplier tube that can be used is R5916 manufactured by Hamamatsu Photonics. If BaFBr:Eu²⁺ is used as a stimutable phosphor, the already mentioned green-light laser emitting pulses of a duration of 2 ns can be used as an exciting light source. In the example under consideration, a gate signal having a time duration of 5 ns is input to the gated photomultiplier tube synchronously with the illumination of the stimutable phosphor with the pulsed exciting light such that the photomultiplier tube remains off as long as the illumination continues but turns on when the gate is controlled after illumination with the exciting light. This procedure enables the stimulated fluorescence from the excited stimutable phosphor to be detected without being affected by illumination with the pulsed exciting light. In other words, the radiation measuring apparatus recited in ~~claim example 8~~ is capable of determining the dose of radiation in a stimutable phosphor without being affected by illumination with the pulsed exciting light.

Page 28, paragraph 2

We now describe an example of ~~claim 9~~ with reference to Fig. 12. ~~Like claims examples 7 and 8, the invention recited in claim example 9 relates to a method applicable to an apparatus for radiation measurement using a stimuable phosphor and which is characterized by an improvement in the manner in which the dose of radiation accumulated in the stimuable phosphor is read. The improved method is particularly applicable to the case where a stimuable phosphor of short fluorescence lifetime ($\leq 2 \mu$) is used as a radiation detecting medium, provided that a moderate intensity of radiation has been accumulated in the stimuable phosphor. In the example under consideration; BaFBr:Eu²⁺ having a fluorescence lifetime of 0.8 μ s is used as the radiation detecting medium.~~

Page 30, paragraph 1

We now describe an ~~example of claim 10~~ with reference to Fig. 14. This is an improvement of a mechanism for illuminating the stimuable phosphor as a radiation detecting medium with exciting light to read the dose of radiation accumulated in the stimuable phosphor and is characterized by using a laterally radiating optical fiber as a radiator of exciting light in the mechanism. The example under consideration is the same as the method ~~recited in claim of example 7~~ which measures the dose of radiation accumulated in the stimuable phosphor, except that the exciting light from the pulsed laser light source is not directly applied to the stimuable phosphor but applied via the illustrated laterally radiating optical fiber. An example of the laterally radiating optical fiber that can be used is LUMINAS V Grade which is a laterally leaky optical fiber manufactured by Asahi Chemical Industry. A conventional optical fiber can be used as a laterally radiating type if a thin layer is removed from the entire circumference. The

use of the laterally radiating optical fiber permits remote sensing by eliminating the need to install the exciting light source at the site of radiation detection.

Page 31, paragraph 1

We now describe an example of ~~claim~~ 11 with reference to Fig. 15. This example is a modification of ~~claim~~ example 10, in which an optical fiber that radiates light from a portion of its circumference as shown enlarged in the inset is used as the lateral radiator in the mechanism for illuminating the stimuable phosphor with exciting light. A conventional optical fiber can be used as such semilaterally radiating type if a thin layer is removed from a limited part of the circumference. The use of a semi-laterally radiating optical fiber eliminates the need to install the exciting light source at the site of radiation detection and permits efficient reading of the dose of radiation in the stimuable phosphor by radiating light only in a specified direction.

Page 32, paragraph 1

We now describe an example of ~~claim~~ 12 with reference to Fig. 16. This example is a modification of ~~claim~~ example 11, in which the semi-laterally radiating optical fiber is overlaid with a light reflector which is remote from the light radiating part of the fiber so that leaking light is sufficiently reflected back to the radiating part to radiate as much light as possible. This design permits more efficient reading of the dose of radiation accumulated in the stimuable phosphor.

Page 32, paragraph 2

We now describe an example of ~~claim~~ 13 with reference to Fig. 17. The radiation detecting portion in this example uses a cylinder of stimuable phosphor; more specifically, it comprises in superposition an optical fiber capable of lateral radiation of light, a stimuable phosphor as a radiation detecting medium that is spaced from the optical fiber, an optical

bandpass filter centered at the wavelength of fluorescence which is disposed outside the stimuable phosphor, and a multiple of wavelength shifting fibers that are sensitive to the wavelength of fluorescence and which are disposed around the optical filter to detect both stimulated fluorescence and prompt fluorescence. The outermost part of the radiation detecting portion is covered with a light shield. The stimuable phosphor is BaFBr:Eu²⁺ that emits stimulated fluorescence at 390 nm which has a lifetime of 0.8 μ s. In view of the wavelength of the stimulated fluorescence which is 390 nm in the example under consideration, a fluorescent plastic fiber having an excitation wavelength range of 320 nm - 395 nm and emitting fluorescence centered at the wavelength of 450 nm is used as the wavelength shifter. The wavelength shifted fluorescence has a lifetime not longer than 10 ns. The radiation detecting portion using the wavelength shifting fiber sensitive to stimulated fluorescence at 390 nm not only enables complete remote sensing but also increases the detecting area of the stimuable phosphor as a radiation detecting medium by a sufficient amount to enhance the sensitivity for radiation detection. The example under consideration can be used as a highly sensitive detector of a radioactive gas that is introduced into the space between the laterally radiating optical fiber and the stimuable phosphor.

Page 33, paragraph 1

We now describe an example of claim 14 with reference to Fig. 18. In this example, too, BaFBr:Eu²⁺ having a fluorescence lifetime of 0.8 μ s is used as a stimuable phosphor. The radiation detecting portion in this example comprises the following components in planar superposition: four optical fibers with a diameter of 1 mm that are capable of lateral radiation of light; a stimuable phosphor as a radiation detecting medium; an optical bandpass filter centered at the wavelength of fluorescence; and four wavelength shifting fibers with a diameter of 1 mm

that are sensitive to the wavelengths of stimulated fluorescence and prompt fluorescence and which are used to detect both types of fluorescence. An exemplary apparatus for measuring radiation using this radiation detecting portion is shown in Fig. 19. Using this radiation detecting portion, one can perform complete remote sensing. In addition, the cross-sectional size of the radiation detecting portion can be reduced to less than 1 cm x 1 cm, which is small enough to permit easy radiation measurement even if the installation area is small or the detecting portion is quite long.

Page 34, paragraph 1

We now describe an example of ~~claim 15~~ with reference to Fig. 20. The radiation detecting portion used in this example has a ribbon array of four optical fibers with a diameter of 1 mm that are capable of lateral radiation of light and which are sandwiched between two units of the following components in planar superposition: a stimuable phosphor as a radiation detecting medium; an optical bandpass filter centered at the wavelength of fluorescence; and four wavelength shifting fibers with a diameter of 1 mm that are sensitive to the wavelengths of stimulated fluorescence and prompt fluorescence and which are used to detect both types of fluorescence. Since the stimuable phosphor is provided on each side of the radiation detecting portion, not only can detection sensitivity be increased but also the direction of incidence of radiation can be estimated.

Page 34, paragraph 2

We now describe an example of ~~claim 16~~ with reference to Fig. 21. As in the previous example, the radiation detecting portion has a ribbon array of four optical fibers with a diameter of 1 mm that are capable of lateral radiation of light and which are sandwiched between two units of the following components in planar superposition: a stimuable phosphor as a radiation

detecting medium; an optical bandpass filter centered at the wavelength of fluorescence; and four wavelength shifting fibers with a diameter of 1 mm that are sensitive to the wavelengths of stimulated fluorescence and prompt fluorescence and which are used to detect both types of fluorescence. The stimuable phosphor on one side is just the same as described above but the stimuable phosphor on the other side is adapted to be capable of detecting neutrons by mixing with Gd which is a neutron converter that converts neutrons to an ionizable radiation. This design allows for detection of neutrons in addition to ionizing radiations such as X-rays and gamma-rays. Some X-rays and gamma-rays are sensitive to the mixture of the neutron converter and the stimuable phosphor but their effects can be corrected on the basis of the data captured with the stimuable phosphor alone; hence, the dose of neutrons can be measured with high precision.

Page 35, paragraph 1

We now describe an example of claim 17 with reference to Fig. 22. In this example, too, BaFBr:Eu²⁺ having a fluorescence lifetime of 0.8 μ s is used as a stimuable phosphor. The radiation detecting portion in this example is in a cylindrical form and comprises in superposition a single optical fiber with a diameter of 1 mm that is capable of lateral radiation of light, a stimuable phosphor as a radiation detecting medium, an optical bandpass filter centered at the wavelength of fluorescence, and a multiple of wavelength shifting fibers that are sensitive to the wavelength of fluorescence and which are disposed around the optical filter to detect both stimulated fluorescence and prompt fluorescence. Using this radiation detecting portion, one can perform complete remote sensing. In addition, the cross-sectional size of the radiation detecting portion can be reduced to less than 1 cm in diameter, which is small enough to permit easy radiation measurement even if the installation area is small or the detecting portion is quite long.

Page 36, paragraph 1

We now describe an example of ~~claim~~ 18 with reference to Fig. 23. In this example, a stimuable phosphor spanning a long distance is used as a radiation detecting medium and in order to ensure that the dose of radiation accumulated in the stimuable phosphor can be read together with the associated position information, a special mechanism is used to illuminate the stimuable phosphor with exciting light of a very short pulse duration.

Page 37, paragraph 1

We now describe an example of ~~claim~~ 19 with reference to Fig. 24. The radiation detecting portion of this example can be made of essentially the same components as in the example of ~~claim~~ 18. The radiator of exciting light in the mechanism for illuminating a stimuable phosphor (radiation detecting medium) with exciting light to read the dose of radiation accumulated in the stimuable phosphor is at least one illuminating optical fiber which consists of a laterally or semi-laterally radiating optical fiber, an optical delay mechanism and an ordinary optical fiber that are connected alternately. The back side of the laterally or semi-laterally radiating optical fiber length is overlaid with the stimuable phosphor as the radiation detecting medium and an optical filter centered at the wavelength of fluorescence which, in turn, is overlaid on the back side with at least one wavelength shifting optical fiber sensitive to stimulated fluorescence. The optical delay mechanism used in the example under consideration is an optical fiber having a length corresponding to a delay time of 30 ns. By increasing the interval between emissions of exciting light from successive laterally or semi-laterally radiating optical fiber lengths, the arrival time of exciting light is sufficiently delayed to ensure that the dose of radiation is correctly determined in each position of measurement.

Page 38, paragraph 1

We now describe an example of ~~claim-20~~ with reference to Fig. 25. The radiation detecting portion used in this example is the same as what is used in the example of ~~claim-14~~. In order to enhance the position resolution for each site of radiation measurement, the stimuable phosphor to be used in the example under consideration must also have a short enough fluorescence lifetime. This need can be met by $\text{Y}_2\text{SiO}_5\text{:Ce}$ which emits stimulated fluorescence having a very short lifetime of 30 ns. The excitation wavelength of this stimuable phosphor is centered at 620 nm. Upon illumination with exciting light, this phosphor emits stimulated fluorescence at 410 nm. Since these characteristics are generally the same as those of BaFBr:Eu^{2+} which are used in the foregoing examples, the exciting light source and the wavelength shifting optical fiber or fibers that are to be used in the example under consideration are also the same as what are used in the foregoing examples. The radiation detecting portion using the stimuable phosphor is provided at each site of measurement and the stimuable phosphor is illuminated with exciting light having a pulse duration no longer than 2 ns via at least one laterally radiating optical fiber. The exciting light source is typically a semiconductor laser. The stimulated fluorescence emitted from the stimuable phosphor is detected with the wavelength shifting fiber radiator. As in the example of ~~claim-18~~, the time of incidence of pulsed exciting light output from the laterally or semi-laterally radiating optical fiber is related to the temporal distribution of the intensity of the stimulated fluorescence output from the wavelength shifting fibers and this relationship is used to determine the continuous distribution of the dose of incident radiation at the specified sites of radiation measurement. To achieve this, the temporal distribution of the fluorescence output from the wavelength shifting fiber is measured with a signal processing circuitry which consists of a photomultiplier tube, a

high-speed DC signal amplifier, an analog/digital converter, a memory circuit and a controlling/data collecting unit as shown in Fig. 25. The analog/digital converter should have a sampling rate of at least 100 MHz. The positional resolution that can be realized is determined by the lifetime of the fluorescence from the stimuable phosphor which is 30 ns in the example under consideration and the best value is about 10 m.

Page 40, paragraph 1

We now describe an example of claim 21 with reference to Fig. 2E. This example is the same as the example of claim 20 (see Fig. 25) except that the signal processing circuitry for measuring the fluorescence output from the wavelength shifting fiber is replaced by a streak camera based technology. To be more specific, the fluorescence output from the wavelength shifting fiber is launched into a streak camera and the temporal distribution of the intensity of stimulated fluorescence is measured at high speed with varying time scan signals being supplied to the deflecting electrodes synchronously with the launching of pulsed exciting light into the semi-laterally radiating optical fiber. The measured temporal distribution is recorded in an imaging device such as a CCD camera. An example of the streak camera that can be used in the example under consideration is C2830 of Hamamatsu Photonics which is capable of high-speed scanning. The recorded data is captured by the data collecting/controlling unit and the distribution of incident radiation doses at the sites of measurement can be determined on the basis of the temporal distribution of the captured fluorescence intensity data. Again, the positional resolution that can be realized is determined by the lifetime of the fluorescence from the stimuable phosphor which is 30 ns in the example under consideration and the best value is about 10 m.

Page 41, paragraph 1

We now describe the invention ~~recited in claim of example 22~~. The apparatus described in connection with ~~the examples of claims 18 - 21~~ can complete the intended measurement within a very short period of time. In ~~the invention of claim~~example 22, the procedure of such measurement is repeated more than once in order to read the signal for the radiation accumulated within the stimuable phosphor in the radiation detecting portion. If the radiation detecting portion is 100 m long, the reading process ends within 1 μ s. This means that even if the stimuable phosphor is illuminated with 1,000 applications of pulsed exciting light for reading the dose of accumulated radiation, the desired data can be collected within 1 ms. The number of times the pulsed exciting light is applied to the stimuable phosphor can be determined in accordance with the optical power of the laser light. The distribution of incident radiation doses at the sites of measurement can be precisely determined on the basis of the temporal distribution of the integral of fluorescence intensity.

Page 42, paragraph 1

We now describe ~~an example of claim 23~~ with reference to Fig. 27. The purpose of this example is to measure radiation with the stimuable phosphor as a radiation detecting medium being provided at two or more sites. The radiation detecting portion comprises in superposition a plurality of stimuable phosphors, an optical fiber for illuminating each stimuable phosphor with exciting light, an optical bandpass filter centered at the wavelengths of prompt fluorescence and the stimulated fluorescence that is emitted from the stimuable phosphors upon illumination with exciting light, and at least one wavelength shifting fiber sensitive to the wavelength of fluorescence that is used to detect the emissions of the stimulated fluorescence and prompt fluorescence. To excite the respective stimuable phosphors, laser light is emitted from a multi-

channel exciting light source and launched into the optical fibers. The sites of measurement can be selectively set by a control unit and stimulated fluorescence is read with a single wavelength shifting fiber. Signal processing is synchronous with the signal for controlling the exciting light source and performed by a conventional apparatus comprising a photomultiplier tube, a high-speed pulsed signal amplifier, a pulse height discriminator, a counter circuit and a control unit.

Page 42, paragraph 2

We now describe an example of ~~claim~~ 24 with reference to Fig. 28. A conventional apparatus for reading radiation image from a stimuable phosphor sheet (commercially available as an imaging plate) comprises a stimuable phosphor sheet, an exciting light source emitting light of a wavelength that can excite the stimuable phosphor, a mechanism for illuminating the stimuable phosphor sheet with a rectangular pattern of the output exciting light, an optical bandpass filter centered at the wavelength of stimulated fluorescence, a wavelength shifter bundle comprising a ribbon array of wavelength shifting optical fibers that can be excited with the stimulated fluorescence, an optical bandpass filter centered at the wavelength of the shifted fluorescence, a photodetector capable of multi-channel detection of the fluorescence emitted from the respective wavelength shifting optical fibers, and a signal processing unit that processes the signals from the multi-channel detector to produce digital signals for constructing a radiation image. ~~Claim-Example 24 recites-illustrates~~ an improvement of this conventional apparatus. In order to illuminate the stimuable phosphor sheet with a rectangular pattern of the exciting light from the light source, laterally radiating optical fibers are arranged on the surface of the stimuable phosphor sheet in a direction perpendicular to the bundle of wavelength shifting optical fibers and the exciting light is launched from the light source into the laterally radiating

optical fibers in turn. As a result, the mechanism for illuminating the exciting light is simplified and the dose of radiation accumulated in the stimuable phosphor sheet can be easily read together with the associated position information.

Page 43, paragraph 1

We now describe an example of ~~claim~~-25 with reference to Fig. 29. In this example, the fluorescence output from both ends of the wavelength shifting fiber in the radiation detecting portion described in ~~claims~~-examples 13 - 17 is passed through an optical bandpass filter centered at the wavelength of fluorescence and then detected with a photomultiplier tube used as the photodetector in the fluorescence detecting mechanism described in ~~claim~~-example 10. By detecting the fluorescence output at both ends of the wavelength shifting fiber in the radiation detecting portion, the efficiency of detection is almost doubled.

Page 44, paragraph 1

We now describe an example of ~~claim~~-26 with reference to Fig. 30. This example is the combination of ~~claims~~-examples 1 and 10 in that the method of radiation measurement recited in ~~claim~~-example 1 is applied to the apparatus for radiation measurement recited in ~~claim~~-example 10. A small radiation detecting portion that is capable of measurement over a long distance is operated by a method of measuring the incident radiation dose through selective detection of stimulated fluorescence and prompt fluorescence at specified time intervals and by a method capable of reading the dose of intense radiation incident within a very short time and, as a result, a high performance apparatus for radiation measurement is realized.

Page 44, paragraph 2

We now describe an example of ~~claim~~-27 with reference to Fig. 31. In this example, the signal reading method recited in ~~claim~~-example 3 is substituted for the conventional pulse

counting method in order to read the signal for stimulated fluorescence in the apparatus recited in ~~claim-example 26~~. The radiation detecting portion used in the example is a planar array comprising in superposition a bundle of laterally radiating optical fibers, a stimuable phosphor as a radiation detecting medium, an optical filter centered at the wavelength of fluorescence, and a bundle of wavelength shifting optical fibers sensitive to stimulated fluorescence. This radiation detecting portion is used to construct a differential and integral type of radiation measuring apparatus that selectively detects stimulated fluorescence and prompt fluorescence at specified time intervals on the basis of two actions of the stimuable phosphor, one for emitting stimulated fluorescence in proportion to the dose of incident radiation upon illumination with exciting light and the other for emitting prompt fluorescence in response to the incident radiation. The fluorescence detecting mechanism is monitored at specified time intervals with a saturation detecting circuit to see if it has failed by saturation with high-intensity radiation; if saturation occurs, stimulated fluorescence is detected after the detecting mechanism has recovered from saturation, thereby reading the dose of high-intensity radiation that was incident within a short time.

Page 46, paragraph 1

We now describe an example of ~~claim-28~~ with reference to Fig. 32. In this example, the stimuable phosphor used as a radiation detecting medium in the apparatus of ~~claim-example 22~~ is replaced by a neutron imaging plate incorporating Gd which is a neutron converter capable of converting neutrons to an ionizable radiation (this plate is commercially available from Fuji Photo Film Co., Ltd. as one of BAS-ND Series neutron imaging plates). By using a radiation detecting medium which is a mixture of the neutron converter and the stimuable phosphor, one

can construct a radiation measuring apparatus that performs the functions described in the previous examples and which has the added capability of measuring neutrons.

Page 46, paragraph 2

We now describe an example of ~~claim~~-29 with reference to Fig. 33. In this example, a neutron imaging plate is used as the detection medium in the method of radiation measurement recited in ~~claim~~-example 2 and a fast neutron moderator in the form of a warhead is provided in front of the imaging plate to allow for detection of fast neutrons. Exciting light is guided by an optical fiber and emitted from within a space created by boring the center of the fast neutron moderator which is typically made of polyethylene.

Page 47, paragraph 1

We now describe an example of ~~claim~~-30 with reference to Fig. 34. The emission characteristics of stimulated fluorescence from the stimuable phosphor as a radiation detecting medium and the phenomenon of fading (i.e., the radiation signal gradually disappears with time) both depend on temperature. To modify the radiation measuring apparatus according to the example of ~~claim~~-26 on the basis of this finding, the temperature of the stimuable phosphor is measured with a temperature sensor and a temperature detecting circuit in the example of ~~claim~~-30. On the basis of the measured temperature, the dose of accumulated radiation that is measured by illumination with exciting light is corrected by the data collecting and processing circuit to ensure precise measurement of radiation dose in spite of variations in the temperature of the radiation detecting portion.